In the Claims

A complete listing of the claims follows immediately hereinafter.

1. (currently amended) A plasma reactor system ~~at least~~ for use in removing an implant crust that is formed as an outermost layer of a photoresist pattern that is supported by a treatment object, said implant crust being formed responsive to exposure of the treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as well as into the photoresist, thereby producing said implant crust, said system comprising:

a treatment chamber within which a plasma is generated using a hydrocarbon gas in combination with oxygen gas in a way which subjects the implant crust to the plasma ~~for use in removal of~~ to remove the implant crust, formed responsive to introduction of said implanted dopant, said plasma being free of halogens, at least to an approximation, to remove the implant crust without the use of introduced halogens.

2. (original) The system of claim 1 wherein said hydrocarbon gas produces low molecular weight radicals in said plasma.

3. (original) The system of claim 2 wherein said low molecular weight radicals include a molecular weight of less than approximately 30.

4. (original) The system of claim 2 wherein said radicals include at least one of CH_2 radicals and CH_3 radicals in the plasma.

5. (canceled)

6. (previously amended) The system of claim 5 wherein said implant crust overlies an unaltered region of an original photoresist layer and said plasma formed using said hydrocarbon gas in combination with oxygen is used to remove said unaltered region of photoresist.

7. (previously amended) The system of claim 6 wherein said implant crust and said unaltered region of said original photoresist layer are simultaneously removed using said plasma formed with said hydrocarbon gas in combination with oxygen gas.

8. (original) The system of claim 7 wherein said plasma is generated with downstream plasma generation means.

9. (original) The system of claim 1 wherein the treatment object is a semiconductor wafer.

10. (original) The system of claim 1 wherein said hydrocarbon gas is in a range of from approximately 15% to 85% of an overall mixture with the oxygen gas.

11. (original) The system of claim 1 wherein said hydrocarbon gas is methane.

12. (original) The system of claim 1 wherein 75% methane and 25% oxygen form an overall gas mixture.

13. (original) The system of claim 1 including an inductive coil for inducing power into the plasma at a power level of at least 200 W.

14. (original) The system of claim 1 including an inductive coil for inducing power into the plasma at a power level of approximately 3000 watts.

15. (original) The system of claim 1 including a parallel plate reactor for generating said plasma.

16. (original) The system of claim 1 including a microwave plasma source for generating said plasma.

17. (original) The system of claim 1 wherein said treatment chamber is at a pressure selected in the range of approximately 0.5 to 15 Torr.

18. (original) The system of claim 1 wherein said treatment chamber is at a pressure of approximately 3 Torr.

19. (original) The system of claim 1 wherein said chamber is at a pressure of approximately 1 Torr.

20. (currently amended) In a plasma reactor system at least for use in removing an implant crust that is formed as an outermost layer of a photoresist pattern that is supported by a treatment object, said implant crust being formed responsive to exposure of the treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as well as into the photoresist, thereby producing said implant crust, a method comprising:

generating a plasma in a plasma chamber using a hydrocarbon gas in combination with oxygen gas such that the plasma is halogen free, at least to an approximation, in a way which subjects the implant crust to the plasma for ~~use in removal of~~ removing the implant crust, previously produced by introduction of said implanted dopant, without the use of introduced halogens.

21. (original) The method of claim 20 wherein said hydrocarbon gas produces low molecular weight radicals in said plasma.

22. (original) The method of claim 21 wherein said low molecular weight radicals include a molecular weight of less than approximately 30.

23. (original) The method of claim 21 wherein said hydrocarbon gas is capable of generating at least one of CH_2 radicals and CH_3 radicals in the plasma.

24. (canceled)

25. (previously amended) The method of claim 24 wherein said implant crust overlies an unaltered region of an original photoresist layer and the method includes using said plasma to remove said unaltered region of photoresist.

26. (previously amended) The method of claim 25 including simultaneously removing said implant crust and said unaltered region of said original photoresist layer using said plasma.

27. (original) The method of claim 26 including downstream generation of said plasma.

28. (original) The method of claim 20 wherein the treatment object is a semiconductor wafer.

29. (original) The method of claim 20 wherein said hydrocarbon gas is in a range of from approximately 15% to 85% of an overall mixture with the oxygen gas.

30. (original) The method of claim 20 wherein said hydrocarbon gas is methane.

31. (original) The method of claim 20 wherein 75% methane and 25% oxygen form an overall gas mixture.

32. (original) The method of claim 20 including the step of inducing power into the plasma at a power level of at least 500 watts.

33. (previously amended) The method of claim 20 including inducing power into the plasma at a power level in a range from approximately 500 to 5000 watts.

34. (previously amended) The method of claim 20 including pressurizing said treatment chamber at a pressure selected in the range of approximately 0.5 to 15 torr.

35. (previously amended) The method of claim 20 including pressurizing said treatment chamber at a pressure of approximately 3 torr.

36. (previously amended) The method of claim 20 including the step of pressurizing said treatment chamber at a pressure of approximately 1 torr.

37. (withdrawn) A plasma reactor system at least for use in removing a process material crust from a treatment object, said system comprising:

a treatment chamber within which a plasma is generated, that is substantially halogen free, using a hydrogen containing gas in combination with oxygen gas such that an overall gas mixture includes at least 15% hydrogen in a way which subjects the process material crust to the plasma for use in removal of the process material crust.

38. (withdrawn) The system of claim 37 wherein said hydrogen containing gas consists essentially of hydrogen gas.

39. (withdrawn) The system of claim 38 wherein each of said hydrogen gas and said oxygen gas make up approximately one-half of the overall gas mixture.

40. (withdrawn) The system of claim 38 wherein said hydrogen gas is provided in the overall gas mixture in a range from approximately 15% to 85%.

41. (withdrawn) The system of claim 38 including pressurizing the treatment chamber at a pressure selected in the range of approximately 0.5 to 15 Torr.

42. (withdrawn) The system of claim 37 wherein said process material is a photoresist and said process material crust is formed by ion implantation of an original photoresist layer on a surface of said treatment object.

43. (withdrawn) The system of claim 42 wherein said process material crust overlies an unaltered region of said original photoresist layer and said plasma formed using said hydrogen gas in combination with oxygen is used to remove said unaltered region of photoresist.

44. (withdrawn) The system of claim 43 wherein said process material crust and said unaltered region of said original photoresist layer are simultaneously removed using said plasma formed with said hydrogen gas in combination with oxygen gas.

45. (withdrawn) The system of claim 37 wherein the treatment object is a semiconductor wafer.

46. (withdrawn) The system of claim 37 wherein said hydrogen containing gas is in a range of from approximately 15% to 85% of an overall mixture with the oxygen gas.

47. (withdrawn) The system of claim 37 including an inductive coil for inducing power into the plasma at a power level of at least 500 Watts.

48. (withdrawn) The system of claim 37 including an inductive coil for inducing power into the plasma at a power level in a range from approximately 500 to 5000 watts.

49. (withdrawn) The system of claim 37 including a parallel plate reactor for generating said plasma.

50. (withdrawn) The system of claim 37 including a microwave plasma source for generating said plasma.

51. (withdrawn) The system of claim 37 wherein said treatment chamber is at a pressure selected in the range of approximately 0.5 to 15 Torr.

52. (withdrawn) The system of claim 37 wherein said treatment chamber is at a pressure of approximately 3 Torr.

53. (withdrawn) The system of claim 37 wherein said treatment chamber is at a pressure of approximately 1 Torr.

54. (withdrawn) In a plasma reactor system at least for use in removing a process material crust from a treatment object, a method comprising the steps of:

generating a plasma in a plasma chamber using a hydrogen containing gas in combination with oxygen gas such that the plasma is substantially halogen free and so that an overall gas mixture includes at least 15% hydrogen in a way which subjects the process material to the plasma for use in removal of the process material crust.

55. (withdrawn) The method of claim 54 wherein said hydrogen containing gas consists essentially of hydrogen gas.

56. (withdrawn) The method of claim 55 wherein each of said hydrogen gas and said oxygen gas make up at least

approximately one-half of the overall gas mixture.

57. (withdrawn) The method of claim 56 wherein said hydrogen gas is provided in the overall gas mixture in a range from approximately 15% to 85%.

58. (withdrawn) The method of claim 55 including pressurizing the treatment chamber at a pressure selected in the range of approximately 0.5 to 15 Torr.

59. (withdrawn) The method of claim 54 wherein said process material is a photoresist and said process material crust is formed by ion implantation of an original photoresist layer on a surface of said treatment object.

60. (withdrawn) The method of claim 54 wherein the treatment object is a semiconductor wafer.

61. (withdrawn) The method of claim 54 wherein said hydrogen is in a range of from approximately 15% to 85% of an overall mixture with the oxygen gas.

62. (withdrawn) The method of claim 54 including the step of inducing power into the plasma at a power level of at least 500 Watts.

63. (withdrawn) The method of claim 54 the step of including inducing power into the plasma at a power level in a range from approximately 500 to 5000 watts.

64. (withdrawn) The method of claim 54 including the step of pressurizing the said treatment chamber at a pressure selected in the range of approximately 0.5 to 15 Torr.

65. (withdrawn) The method of claim 54 including the step of pressurizing the treatment chamber at a pressure of approximately 3 Torr.

66. (withdrawn) The method of claim 54 including the step of pressurizing the treatment chamber at a pressure of approximately 1 Torr.

67. (currently amended) A plasma reactor system ~~at least~~ for ~~use in~~ removing an implant crust that is formed as an outermost layer of a photoresist pattern that is supported by a treatment object, said implant crust being formed responsive to exposure of the treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as well as into the photoresist, thereby producing said implant crust, said system comprising:

a treatment chamber within which a halogen free plasma is generated using a gas in combination with oxygen gas in a way which produces at least one of CH_2 radicals and CH_3 radicals in said plasma to subject the implant crust to the plasma ~~for use in removal of~~ to remove the implant crust previously formed responsive to the introduction of said implanted dopant.

68. (currently amended) In a plasma reactor system ~~at least~~ for ~~use in~~ removing an implant crust that is formed as an outermost layer of a photoresist pattern that is supported by a treatment object, said implant crust being formed responsive to exposure of the treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as

well as into the photoresist, thereby producing said implant crust, a method comprising:

generating a halogen free plasma in a plasma chamber using a gas in combination with oxygen gas in a way which produces at least one of CH_2 radicals and CH_3 radicals in the plasma and which subjects the implant crust to the plasma ~~for use in removal of~~ to remove the implant crust, previously produced by introduction of said implanted dopant, thereby removing the implant crust without the use of introduced halogens.

69. (withdrawn) A plasma reactor system at least for use in removing a photoresist layer from a treatment object, said photoresist layer including an outermost crust formed by exposure of the photoresist to an ion implantation source, said system comprising:

treatment chamber within which said treatment object is supported;

first means for introducing a first halogen free plasma in said treatment chamber using hydrogen gas in combination with oxygen gas in a way which subjects the outermost crust to the first plasma to remove at least a substantial portion of the outermost crust so as to leave an innermost portion of said photoresist layer on the treatment object;

second means for use in removing at least a substantial part of said innermost portion of said photoresist layer such that a residue remains on the treatment object, said residue relating to at least one of the outermost crust and the innermost portion of the photoresist layer; and

third means for generating a second halogen free plasma using a hydrocarbon gas in combination with oxygen gas and for exposing the residue to the second plasma to remove said residue from said treatment object.

70. (withdrawn) In a plasma reactor system at least for use in removing a photoresist layer from a treatment object, said photoresist layer including an outermost crust formed by exposure of the photoresist to an ion implantation source, a method comprising:

supporting said treatment object within a treatment chamber;

producing a first halogen free plasma using hydrogen gas in combination with oxygen gas and subjecting the outermost crust of the treatment object in said treatment chamber to the first plasma to remove at least a substantial portion of the outermost crust so as to leave an innermost portion of said photoresist layer on the treatment object;

removing at least a substantial part of said innermost layer of said photoresist layer such that a residue remains on the treatment object, said residue relating to at least one of the outermost crust and the innermost portion of the photoresist layer; and

generating a second halogen free plasma using a hydrocarbon gas in combination with oxygen gas and exposing the residue to the second plasma to remove said residue from said treatment object.

71. (withdrawn) A plasma reactor system at least for use in removing a photoresist layer from a treatment object, said photoresist layer including an outermost crust formed by exposure of the photoresist to an ion implantation source in a way which may additionally form implant residues, said system comprising:

a treatment chamber within which said treatment object is supported;

first means for introducing a first plasma in said treatment chamber using hydrogen gas in combination with oxygen gas such that the first plasma is substantially free of halogens and in a way which subjects at least the outermost crust to the first plasma to remove at least a portion of the outermost crust so as to leave an underlying portion of said photoresist layer on the treatment object along with at least a portion of said implant residues; and

second means for generating a second plasma using a hydrocarbon gas in combination with oxygen gas such that the second plasma is substantially free of halogens and for exposing the underlying portion of the photoresist layer and any remaining portion of the implant residues to the second plasma for removal from said treatment object.

72. (withdrawn) The system of claim 71 wherein said first means removes a substantial part of said outermost crust such that said underlying portion of the photoresist corresponds to an unaltered photoresist region previously disposed beneath the outermost crust and said second means removes a substantial part of said underlying portion of the photoresist.

73. (withdrawn) In a plasma reactor system at least for use in removing a photoresist layer from a treatment object, said photoresist layer including an outermost crust formed by exposure of the photoresist to an ion implantation source in a way which may additionally form implant residues, a method comprising:

supporting the treatment object in a treatment chamber;

introducing a first plasma in said treatment chamber formed using hydrogen gas in combination with oxygen gas such that the first plasma is substantially free of halogens and in a way which subjects at least the outermost crust to the first plasma to remove at least a portion of the outermost crust so as to leave an underlying portion of said photoresist layer on the treatment object along with at least a portion of said implant residues; and

generating a second plasma using a hydrocarbon gas in combination with oxygen gas such that the second plasma is substantially free of halogens and exposing the underlying portion of the photoresist layer and any remaining portion of said implant residues to the second plasma for removing the innermost portion of the photoresist layer and the remaining implant residues from said treatment object.

74. (withdrawn) The method of claim 71 wherein said first means removes at least a substantial part of said outermost crust such that said underlying portion of the photoresist corresponds to an unaltered photoresist region previously disposed beneath the outermost crust and said second means removes a substantial part of said underlying portion of the photoresist.

75. (currently amended) A plasma reactor system ~~at least for use in removing~~ configured to remove a process residue from a treatment object, which process residue is formed on the treatment object, at least in part, as a result of removing an ion implanted photoresist from the treatment object, said ion implanted photoresist crust being formed responsive to exposure of the treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as well as into the photoresist such that said residues at least contain an implant dopant species, said system comprising:

a treatment chamber within which a plasma is generated using a hydrocarbon gas in combination with oxygen gas in a way which subjects the process residue including the implant dopant species to the plasma ~~for use in removal of~~ to remove the process residue including said implanted dopant therein, said plasma being free of halogens, at least to an approximation, to remove the process residue containing the dopant species without the use of halogens.

76. (currently amended) In a plasma reactor system ~~at least~~ for ~~use in~~ removing a process residue from a treatment object, which process residue is formed on the treatment object, at least in part, as a result of removing an ion implanted photoresist from the treatment object, said ion implanted photoresist crust being formed responsive to exposure of the

treatment object to a high dose ion implant which introduces an implanted dopant into the treatment object as well as into the photoresist such that said residues at least contain an implant dopant species, a method comprising:

generating a plasma in a plasma chamber using a hydrocarbon gas in combination with oxygen gas such that the plasma is halogen free, at least to an approximation, in a way which subjects the process residue including the implant dopant species to the plasma for use in removal of the process residue along with the implant dopant species therein to remove the process residue containing the implant species without the use of halogens.

77. (withdrawn) A plasma reactor system at least for use in removing a process residue from a treatment object, which process residue is formed on the treatment object, at least in part, as a result of removing an ion implanted photoresist from the treatment object, said system comprising:

a treatment chamber within which a plasma is generated, that is substantially halogen free, using a hydrogen containing gas in combination with oxygen gas such that an overall gas mixture includes at least 15% hydrogen in a way which subjects the process residue to the plasma for use in removal of the process residue.

78. (withdrawn) The system of claim 77 wherein said hydrogen containing gas consists essentially of hydrogen gas.

79. (withdrawn) In a plasma reactor system at least for use in removing a process residue from a treatment object, which process residue is formed on the treatment object, at least in part, as a result of removing an ion implanted photoresist from the treatment object, a method comprising:

generating a plasma in a plasma chamber using a hydrogen containing gas in combination with oxygen gas such that the plasma is substantially halogen free and so that an overall gas mixture includes at least 15% hydrogen in a way which subjects the process residue to the plasma for use in removal of the process residue.

80. (withdrawn) The system of claim 77 wherein said hydrogen containing gas consists essentially of hydrogen gas.

81. (previously presented) The system of claim 1 wherein 50% methane and 50% oxygen form an overall gas mixture.

82. (previously presented) The method of claim 20 wherein 50% methane and 50% oxygen form an overall gas mixture.

83. (new) A method for treating a workpiece, comprising:

forming a patterned layer of photoresist on a device side of the workpiece;

exposing the photoresist and a selected region of the workpiece to a high dose ion implantation to implant a dopant species into the selected region of the workpiece as well as into said photoresist to produce an implant crust as an outer layer of the photoresist in an interaction responsive to implantation of said dopant species;

generating a plasma using a hydrocarbon gas in combination with oxygen gas such that the plasma is halogen free, at least to an approximation; and

exposing the implant crust to the plasma to remove the implant crust, previously produced by introduction of said implanted dopant.

84. (new) The method of claim 83 including selecting the implant species as one of arsenic, phosphorus and boron.

85. (new) The method of claim 83 including exposing said workpiece with an ion energy ranging from 5KeV to 500 KeV and an implant ion dose greater than 1.0×10^{15} ions/cm^2.

86. (new) The method of claim 83 wherein the hydrocarbon gas is methane.

87. (new) The method of claim 83 wherein 50% methane and 50% oxygen form an overall gas mixture.